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ABSTRACT

This paper describes a professional development program created to establish a new role for junior high school science teachers--the Support Teacher program. The program, developed through the collaboration of the American Federation of Teachers, Michigan State University, and Toledo (Ohio) Public Schools, provided a mechanism for developing local experts who possessed the skills and knowledge around which productive interactions with colleagues could occur. The focus of this paper is on the description and outcomes of learning and instruction of the Science Support Teacher. During fall 1987, 8 teachers from 4 Toledo junior high schools were provided with over 60 hours of intensive preparation to: (1) update their knowledge about current research on teaching and learning science; and (2) provide background and guided practice in working with professional peers in a supportive role. The training consisted of college meetings and readings of selected literature related to improvement in the curriculum, student learning, and science instruction. Some support teachers worked in classrooms and observed instruction and provided feedback. A "Teaching Style Inventory," teacher interviews, curriculum documentation, and student assessment were used to measure the outcomes of the program. It is concluded that the program provided the opportunity for teachers to improve the quality of their classroom instruction at a departmental level in their schools. The Support Teachers reported that their students responded positively to new techniques and instructional ideas they had implemented. Moreover, teachers demonstrated increased confidence and competence which resulted from dialogues with their peers and from engaging collaboratively in significant professional growth activities. A list of the literature read and discussed by Support Teachers during their training sessions is appended. (PR)

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Research Series No. 212

IMPROVING LEARNING AND INSTRUCTION
IN JUNIOR HIGH SCHOOL SCIENCE CLASSES
THROUGH THE ROLE OF THE SUPPORT TEACHER

Anne L. Madsen and James J. Gallagher

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The **Institute for Research on Teaching** was founded in 1976 at Michigan State University and has been the recipient of major federal grants. Funding for IRT projects is currently received from the U.S. Department of Education, Michigan State University, and other agencies and foundations. IRT scholars have conducted major research projects aimed at improving classroom teaching, including studies of classroom management strategies, student socialization, the diagnosis and remediation of reading difficulties, and school policies. IRT researchers have also been examining the teaching of specific school subjects such as reading, writing, general mathematics, and science and are seeking to understand how factors inside as well as outside the classroom affect teachers. In addition to curriculum and instructional specialists in school subjects, researchers from such diverse disciplines as educational psychology, anthropology, sociology, history, economics, and philosophy cooperate in conducting IRT research. By focusing on how teachers respond to enduring problems of practice and by collaborating with practitioners, IRT researchers strive to produce new understandings to improve teaching and teacher education.

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Abstract

This paper describes a professional development program created to establish a new role for junior high school science teachers--the Support Teacher Program. The program developed through the collaboration of the American Federation of Teachers, Michigan State University, and Toledo Public Schools. The Support Teacher Program started in 1987 and continued through 1992. It is directed by James J. Gallagher and Perry E. Lanier from Michigan State University. Eight junior high school science and mathematics teachers participated with Gallagher and Lanier to establish a program that improved learning and instruction and established a new professional role for teachers. The focus of this paper is on the description of and outcomes for learning and instruction of the Science Support Teachers.

IMPROVING LEARNING AND INSTRUCTION
IN JUNIOR HIGH SCHOOL SCIENCE CLASSES
THROUGH THE ROLE OF THE SUPPORT TEACHER

Anne L. Madsen and James J. Gallagher[1]

Research on science learning and instruction in concert with national efforts to reform science education have called for changes in the curriculum and instruction of school science. In its report, Educating Americans for the 21st Century, the National Science Board Commission on Precollege Education in Mathematics, Science and Technology (NSBC, 1983) reported,

> The science that is taught is too rarely demonstrated to be relevant to the concerns of students at their particular stage of development. Only a relatively few are turned on by the natural curiosity that traditionally motivates scientific careers. Even fewer students have the opportunity to see the power of scientific investigation which also stimulates interest. (p. 29)

The problems of low student participation and achievement in science are due, in part, to the quality of instruction they receive. Providing students with the opportunity to achieve levels of excellence in science requires significant improvement in the instruction that currently exists.

Advocates of improving science education have suggested implementing a more nontraditional instructional approach. Such an approach was noted in the report of the Working Group on Middle School (Junior High) Grades 6-8 in Educating Americans for the 21st Century (NSBC, 1983):

> The middle school experience should enhance and further develop the basic skills of science introduced at the elementary school level. Academic growth and challenge should be developed through the exploration and application of scientific concepts.
>
> - Concrete experiences should be used to build on and further develop the basic skills of science. . . .
> - Though the emphasis of the program should focus on concrete experiences, problem solving and logical reasoning experiences should be interwoven so that students can ask questions, manipulate variables, make generalizations and develop concepts.
> - The program should reflect decision making so that students can evaluate personal and societal implications in regard to science and technology. (pp. 39-40)

The Working Group suggests specific recommendations for the professional development of science teachers:

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[1]Anne L. Madsen, an assistant professor in the Department of Curriculum and Instruction at The University of Texas at Austin, is a senior researcher with the Support Teacher Project. James J. Gallagher, professor of teacher education at Michigan State University, is a senior researcher with the project.

- Opportunities are necessary for formal and informal ongoing staff development/training in the areas of science curriculum, adolescent behavior, classroom management and new technologies.
- Support structures to assist teachers with state of the art ideas, resources or material. (p. 40)

Support Teacher Program

Built around the concept of teacher as instructional leader, the role of Support Teacher provided a mechanism for developing local experts who possessed the skills and knowledge around which productive interactions with colleagues occurred. It was also a vehicle for creating an environment in which teachers assisted one another in self-appraisal and self-improvement to the benefit of their students. Through this new role, the Support Teachers and their colleagues became better prepared to teach science, were more highly motivated, and shared a collective commitment to the teaching profession.

Theoretical Model

The goals of the program were to increase the Support Teachers' knowledge, improve instructional practices, and prepare them to conduct staff-development activities. It required an innovative staff-development model that featured

1. Collaboration of school personnel, union officials, and university-based researchers
2. Use of results, conclusions, and implications of extensive research on teaching, including studies of actual classroom actions
3. Establishment of a professional role in schools and preparing junior high school science teachers to work in schools in a new role as exemplary practitioners and leaders in professional development activity
4. Production of a framework for introducing and implementing improvements in classroom practice

The Framework for Guiding Instructional and Curricular Changes

The Support Teachers developed plans to implement curricular and instructional changes in their classrooms and those of their colleagues. These changes centered around the idea of teaching science from a conceptual orientation. The American Association for the Advancement of Science (AAAS), in What Science Is Most Worth Knowing? (1987), describes the nature of nontraditional practices that "reflect both research and the current practice of good teachers" (p. 162). These include the following points:

- Learning science . . . should be a lively affair--active, participatory, nonbookish.
- Teaching should begin with phenomena--the things and events in the real world of young people.
- The anxiety that many students have about . . . science should be recognized and relieved.
- Science . . . teaching should strive to foster curiosity, imagination, and creativity.
- A spirit of healthy skepticism should pervade the teaching of science. . . .
- Students should have repeated practice in collecting, describing and interpreting data.
- Learning science . . . should often be a group effort
- Teaching should take its time. (pp. 162-169)

These recommendations were used by the Support Teachers as they developed instructional improvement plans to be implemented in their classrooms and those of their colleagues.

Activities of the Support Teachers

The school administration of each school provided each Support Teacher with a half-day instructional release time to conduct their support activities. During Fall 1987, four science teachers were selected by their peers and administrators from each of four Toledo junior high schools. From February to August 1988, the teachers were provided with over 60 hours of intensive preparation that included (a) updating their knowledge about current research on teaching and learning science and (b) providing background and guided practice in working with professional peers in a supportive role.

The Support Teachers attended meetings with Michigan State University (MSU) staff and read selected literature related to improvement in the curriculum, student learning, and their science instruction. A listing of the literature the Support Teachers read and discussed is included in the Appendix. They attended an intensive summer program at MSU where support activities for the 1988-89 academic year were planned.

After the first academic year of the program each Support Teacher had created a role unique to his/her own situation. There were some common characteristics, such as conducting regular Support Teacher meetings and reviewing and discussing literature related to science education. Some Support Teachers worked in classrooms with their colleagues and observed instruction and provided feedback. The MSU staff met with them monthly in their schools and assisted them with instructional improvements and provided support to them in their role as Support Teachers.

The Question Guiding the Inquiry and the Data Collected

The question guiding this inquiry was, "What is the nature and degree of change in the quality of science instruction, given this restructured staffing pattern?" Five kinds of data were collected: (a) Staff members collected documentation as they engaged in technical assistance; (b) four external observers followed the Support Teachers in each school and documented the activities and events of Support Teaching; (c) a teacher interview was conducted four times; (d) the teaching style inventory was completed four times; and (e) student data was collected on a limited scale.

Preliminary Results and Outcomes of the Support Teacher Program

Results from Teaching Style Inventory, teacher interview, documentation of their curriculum, and student assessment suggest that thoughts and practices of the Support Teachers had changed.

The Teaching Style Inventory

The purpose of the teaching style inventory was to learn about the teachers' thoughts about instruction, student learning, and the nature of the science content. Examples of the questions for Parts I and II of the Teaching Style Inventory are in Figure 1. The Teaching Style Inventory was administered (a) at the start of the program; (b) after four months of participation in program activities; (c) following an intensive summer program; and (d) at the end of the first school year.

Analysis of the Teaching Style Inventory

The Teaching Style Inventory consisted of four sections of which two were used in the analysis--Part I (classroom procedures) and Part II (teaching strategies). The method of analysis captured changes in the teachers' thinking. This method compared the teachers' actual response with an ideal response for each item. The ideal response reflects the kind of nontraditional instruction described in the AAAS (1987) report, What Science Is Most Worth Knowing? If a teacher's actual response to an item was 2 and the ideal response was 5, the difference of 3 (absolute value) was recorded. A sum of the differences for all the items was calculated for each survey. The difference between the sum on the first and last survey represented the amount of change which occurred. **The lower the number, the closer the teacher's actual responses were to the ideal.** A total score of 0-43 on the Teaching Style

PART I CLASSROOM PROCEDURES

Check the point within each of the following scales which most accurately describes your science class.

1. Almost all help is initiated by students asking for it. ______1
______2
______3
______4
Almost all help is initiated by my seeing the need for it. ______5

4. In class, students frequently work together on assignments. ______1
______2
______3
______4
Students seldom work together on assignments in class. ______5

5. Hands-on lab work is a regular part of my science class. ______1
______2
______3
______4
Hands-on lab work is rarely part of my science class. ______5

9. When I teach a new topic, I spend a good deal of time (1/3) trying to teach students to see similarities and differences between new and previously learned science ideas. ______1
______2
______3
New topics are generally taught with limited reference to previously learned science ideas. ______4
______5

11. In my science classes, a majority of the time is spent in helping students learn scientific vocabulary. ______1
______2
______3
In my science classes, a majority of time is spent on understanding and applying science principles. ______4
______5

13. In my science classes, I stress logical reasoning. ______1
______2
______3
In my science classes, I stress understanding of terminology. ______4
______5

Figure 1. Science Teaching Style Inventory (selected items).

PART II: INSTRUCTIONAL STRATEGIES

How frequently do you use the strategy in your class?

	About every day	Once/week or more	A few times/month	Once/month or less	Don't use
21. Whole class instruction.	O	O	O	O	O
22. Whole class discussion.	O	O	O	O	O
23. Small group work other than lab work.	O	O	O	O	O
24. Laboratory work.	O	O	O	O	O
25. Films, film strips, video tapes.	O	O	O	O	O
26. Individual seatwork during which I move around the room and help individual students.	O	O	O	O	O
27. Individual seatwork during which I do routine paperwork.	O	O	O	O	O
28. Posing open ended questions.	O	O	O	O	O
29. Gathering and organizing students' responses.	O	O	O	O	O
30. Teacher demonstrations.	O	O	O	O	O
31. Analysis of data from labs or demonstrations.	O	O	O	O	O

Figure 1. (cont'd).

Inventory indicates responses close to the ideal response for every item. This score suggests a nontraditional instructional approach. However, a total score of **129-172** indicates responses far from the ideal, which suggests a more traditional instructional approach. The results of the four surveys for each teacher are presented in Table 1 and Figure 2.

Discussion of the Results on the Teaching Style Inventory

The results of the Teaching Style Inventory indicate that the science Support Teachers had incorporated many recommendations for improving science instruction into their beliefs about teaching. Analysis of the survey data suggest the following points:

1. The teachers moved from a more traditional view of teaching and learning to a more nontraditional view.
2. During the teachers' involvement in the program their thoughts changed at different rates. Some teachers changed their thinking about teaching and learning before others. The greatest range of scores occurred between the second and third survey.
3. By the fourth survey the responses of all the teachers were in close agreement. They were thinking alike in nontraditional ways.

Analysis of the observational data of actual classroom practice lagged somewhat behind the survey responses. That is, although the teachers had changed their thinking, they were not able to implement simultaneously a nontraditional instructional approach in their classes. This was a point of frustration for each Support Teacher--knowing what they wanted to change in their instruction and not being able to accomplish it as fast and with as much success as they would have liked.

The Support Teacher Interviews

The interview questions focused on three categories--tasks, discourse, and environment--recommended in the National Council of Teachers of Mathematic's (NCTM) Professional Standards for Teaching Mathematics (1991, p. 20) as areas of instructional improvement. The Support Teachers used three categories to plan and implement changes in their science instruction. These categories are described below.

- Worthwhile Mathematical [Science] Tasks
  Tasks are the projects, questions, problems, constructions, applications, and exercises in which students engage
- Discourse
  Discourse refers to the ways of representing thinking, talking, and agreeing and disagreeing that teachers and students use to engage in those tasks

- Environment

  Environment represents the setting for learning It is the unique interplay of intellectual, social, and physical characteristics that shapes the ways of knowing and working that are encouraged and expected in the classroom

The Support Teachers were interviewed four times: (1) March 1988; (2) September 1988; (3) June 1989; and (4) May 1990. Each interview lasted about one-and-a-half hours. The interview question selected for analysis are listed in Figure 3.

Analysis of the Teacher Interviews

An instrument was developed to measure the degree to which teachers' thoughts and practices reflected traditional or nontraditional instruction. Three categories were used to analyze their responses: content, communication patterns, and the learning environment. The categories emerged from a synthesis of the research on learning and instruction as areas of instruction which could be identified as traditional or nontraditional. The three categories of the NCTM Standards (1991) described the optimal level (level 1) to which the teachers' responses were measured.

The categories were used to analyze the interview responses. A level 3 in a category represented a traditional instructional approach, a level 1 characterized a nontraditional approach, and a level 2 (transitional) indicated instructional thoughts or practices which were improved from level 3, but not yet optimal (as in level 1).

The content of the science curriculum. This category included the orientation of the content, topics that were covered, the tasks which were selected, and how learning was evaluated. The first category in the NCTM Standards (1991, pp. 25-32), "Worthwhile Mathematical Tasks," represents instruction at a level of 1. Interview questions 1, 6, 10, and 13 are in this category.

The three levels in this category are described in Figure 4. Segments from the first and last interview with Larry Brown.[2]

Larry Brown was asked, "What are the big ideas in 7th/8th grade science?"

> March 1988
> I follow the curriculum. I teach cells and cellular parts, respiration, various kinds of organisms, the kingdoms, systems, plants, and photosynthesis.

---

[2]Names of all Support Teachers are pseudonyms.

Table 1

Results of the Teaching Style Inventory

	Teaching Style Inventory: Parts I and II				
Support Teachers	3/88	9/88	6/89	5/90	Change (3/88 to 6/89)
Larry Brown	73	63	51	50	Δ 23
Victoria Dennis	89	89	59	54	Δ 35
Patrick Mitchell	94		69	55	Δ 39
Lisa Reasoner	89	75	71	62	Δ 27

Note: An IDEAL score is from 0 to 43.

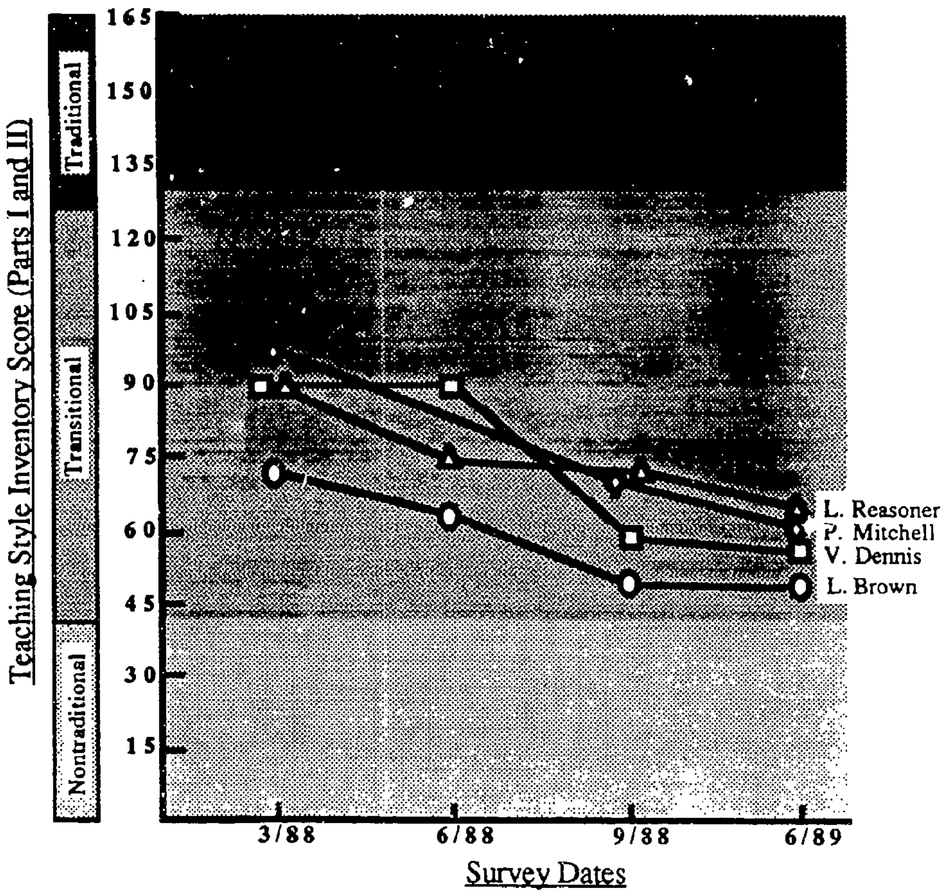

Figure 2. Results of the Teaching Style Inventory.

INTERVIEW QUESTIONS

1. What are the big ideas in _____grade _____science?

2. How do you know when a class period is/is not going well?
Describe a class period that you thought went well recently.

4. What motivates your students to learn the content?
What motivates your students to complete their assignments?

6. How important is practice in your classes?

7. One frequently hears the statement, *"It is important that students understand the content."*
   (a) What does that mean to you?
   (b) How do you know when students do not understand the content?

9. What characteristics do you like to see in your students?
What characteristics do you like to see in your classes?

10. How would you describe your role as teacher?

11. What is your interpretation of the Support Teacher role?

12. What would improve the learning opportunities for your students?

13. What improvements would you suggest on a school-wide basis?

14. How do you assess the Support Teacher Program activities so far?

Figure 3. Support Teacher interview.

LEVEL 1: Nontraditional	LEVEL 2: Transitional	LEVEL 3: Traditional
Concept orientation with linkages to other content or topics.	Concept orientation with no linkages to other content or topics.	Procedural/computational orientation.
Topics/units focus on unifying concepts.	Familiar topics/units set in a new context.	Topic-centered curriculum.
Tasks are interesting/challenging and engage students in active experiences that enhance conceptual understandings.	Tasks are interesting although routine and focus on the concept studied.	Tasks are routine and used to develop skills.
Evaluation includes paper & pencil tests, interviews, and observations focused on conceptual understandings.	Evaluation consists of paper & pencil tests which measure procedural and concept understandings.	Evaluation consists of paper & pencil tests to measure procedural knowledge.

Figure 4. Science content and the curriculum.

May 1990
There is not enough time to cover the big ideas, like cells. I have covered less this year than last year. The big idea has led to a lot of frustration with me. The big ideas are the same as they used to be. The problem is that I don't have enough time to cover them. I am trying to have a common thread throughout the year. I still haven't gotten to the point where I can see big differences in the kids, because we still have to grade them A, B, C, D. The class climate has changed because of the big ideas and trying to make them think.

In the first interview, Larry described a science curriculum that represented a traditional approach--that is, following the standard curriculum and the textbook. However, by the last interview his thinking changed to where he now viewed the content of the science curriculum very differently. His focus was now on the big ideas and unifying concepts and the connections he made between units of content. Similar changes occurred in the thinking of the other three Support Teachers.

The patterns of communication. This category considered how the teacher questioned, explained, and discussed science concepts with students and the degree to which the students participated in classroom communication. The category of "Discourse" in NCTM's Standards (1991) reflects instruction at a level of 1. The interview questions 7, 10, and 12 are related to this category.

The three levels of communication are presented in Figure 5. This is followed by the responses of Victoria Dennis to a question related to communication. Victoria Dennis was asked, "One frequently hears the statement, 'It is important that students understand the content.' (a) What does that mean to you? and (b) How do you know when students do not understand the content?" Her responses are listed as follows:

March 1988
(a) The content is getting the information that is in the textbook. I think it is important, but before I can get to the content I have to convince them that they can get the information.
(b) My students tend to question me. I frustrate them a lot because I never repeat myself. I will say the same thing in many ways.

May 1990
(a) If they understand the idea they will be able to understand the concept--they will be able to explain and give more than one-word answers. Many students will say to me, "There goes that WHY question again." They are not giving me the one word answers anymore. They are now able to explain. I used to accept one-word answers.
(b) They don't understand when they keep their head down and there is no eye contact. They cannot give me an answer outside of the book. I don't depend on a test score as much as I did.

In the last interview, Victoria talked about the importance of communicating with students in order to learn about their understanding. She had changed her thoughts about student learning and the value of communication. Previously, she measured understanding by how well the students answered questions

on a test or quiz. Now, understanding was assessed through discussions of the concepts or by the students' application of the concepts to new situations.

The social organization and the learning environment. This category considered how students were organized for learning, how instructional strategies were used to promote learning, how the curriculum was organized for learning, and how instructional time was spent. The recommendations in NCTM's Standards (1991, pp. 57-62) third category, "Environment," reflects a level of 1 in this analysis. The interview questions 2, 4, 9, 10, 12, were related to this category. The three levels in the category, the learning environment are described in Figure 6.

Patrick Mitchell was asked, "What characteristics do you like to see in your students and your classes?"

> March 1988
> Do what they are told. Follow directions. Pay attention. Ask questions.
> May 1990
> Students who are aggressive in their work. Taking part in the class. Students who contribute. Students who show legitimate interest. Students who bring things into class. Students who want to improve. It is all those positive things and attitudes. Students who are not afraid to contribute or to be wrong. I try to find the right things and not be negative to the kids.

In the first interview, Patrick liked students who followed the rules and did what was expected of them. By the last interview, his attitude and thinking had changed. He now enjoyed students who were active and participating in their learning. In the last interviews, the Support Teachers all mentioned that they enjoyed students who were involved and enthusiastic in actively learning science.

The four interviews of each teacher were analyzed using the categories described above. Their response to each question was assigned a level (1, 2, or 3) and then compared across the four interviews. Each teacher's levels of responses for the four interviews are included in Figures 7, 8, 9, and 10. The results indicate that changes in the teachers' thinking evolved over time and occurred at different rates.

A total score was obtained for each interview. This was the sum of the levels of the responses to the questions on each interview. A level of 1 represents a nontraditional orientation; therefore, the total score for the responses of the interviews over time should move closer to the ideal total score of 11. Table 2 and Figure 11 represent the total scores for the Support Teachers across the four interviews.

LEVEL 1: Nontraditional	LEVEL 2: Transitional	LEVEL 3: Traditional
Instructional is guided-discovery with active student participation.	Instruction is mostly demonstration with limited student participation.	Instruction is demonstration without student participation.
Teacher's questions are open-ended and require students to provide an explanation. Controlled practice is used to promote student understanding.	Teachers questions require students to give some explanation.	Teacher's questions require one-word responses from students.
Explanations embellish and enrich the concept/idea being studied.	Teacher's explanations focus on some concepts or procedures.	Teacher's explanations focus on procedures or definitions.
Discussions are interesting, meaningful and students actively initiate thoughts, conjectures, and ideas.	Discussions are focused on concepts, but students don't initiate the ideas.	Discussions are limited to the development of a skill, definition or procedure.
Feedback is specific and related to the students' understanding of the concept or idea.	Feedback is concept-related but not focused on student understanding.	Feedback is used to keep students on task.

Figure 5. Communication patterns.

LEVEL 1: Conceptual/Nontraditional	LEVEL 2: Transitional	LEVEL 3: Procedural/Traditional
Cooperative groupings are used and the activities promote the development of concept understanding.	Students work occasionally in groups, but tasks are not developed purposefully for the groups.	Students are expected to work individually on their tasks.
Concrete manipulatives illustrations, and activity-based experiences are used to help students understand the concepts being studied.	Concrete manipulatives and illustrations are demonstrated by the teacher to help students better understand the concepts.	Manipulatives and illustrations are not used or are used in ways that promote student understanding of the content.
The curriculum integrates concepts and ideas through strands which connect and unify units of content.	The curriculum is changing to reflect concepts and ideas. The teacher is relying less on the textbook for curriculum planning.	The curriculum is textbook-bound and fragmented into unrelated units and topics.
Students are engaged in content related activities before and after the lesson.	The teacher inconsistently plans for students to work on a task before or after the lesson.	Students spend time socializing before and after the lesson.

Figure 6. The learning environment.

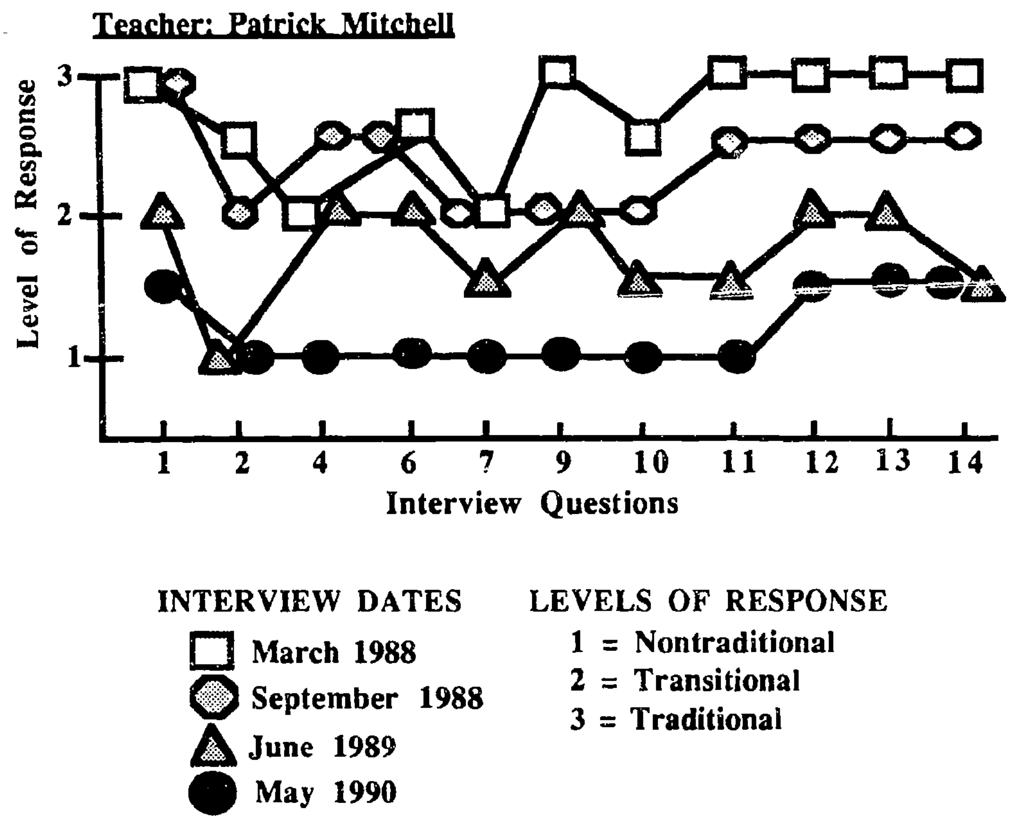

Figure 7. Levels of interview responses of Patrick Mitchell.

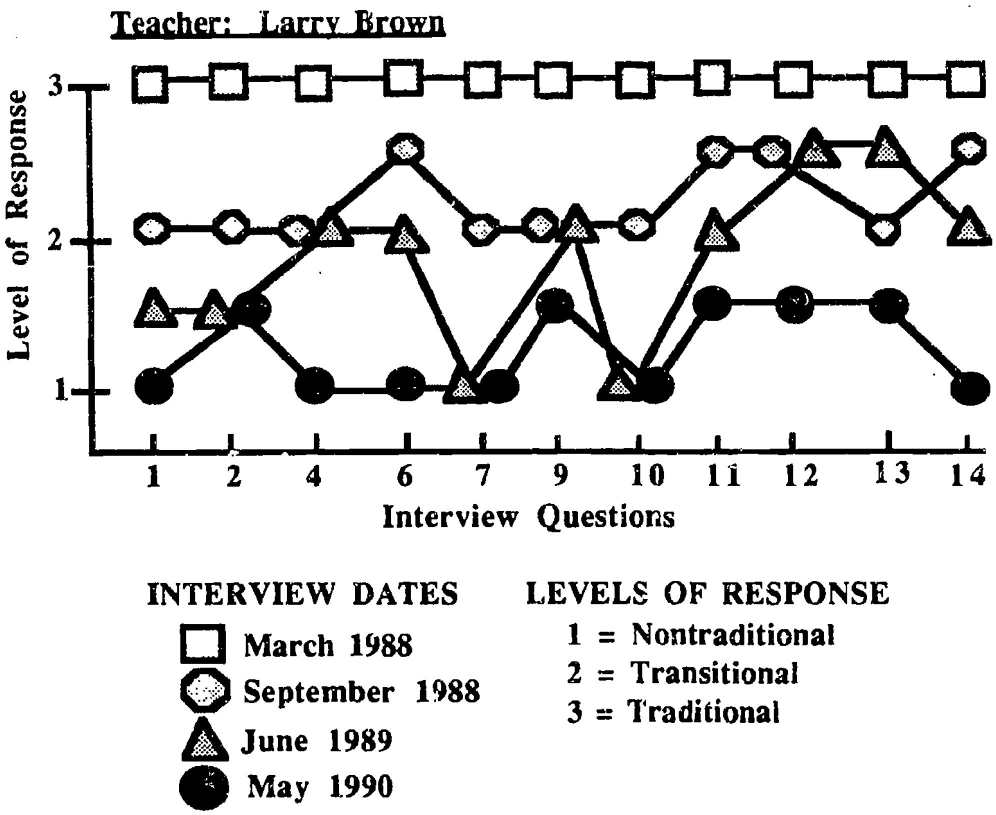

Figure 8. Levels of interview responses of Larry Brown.

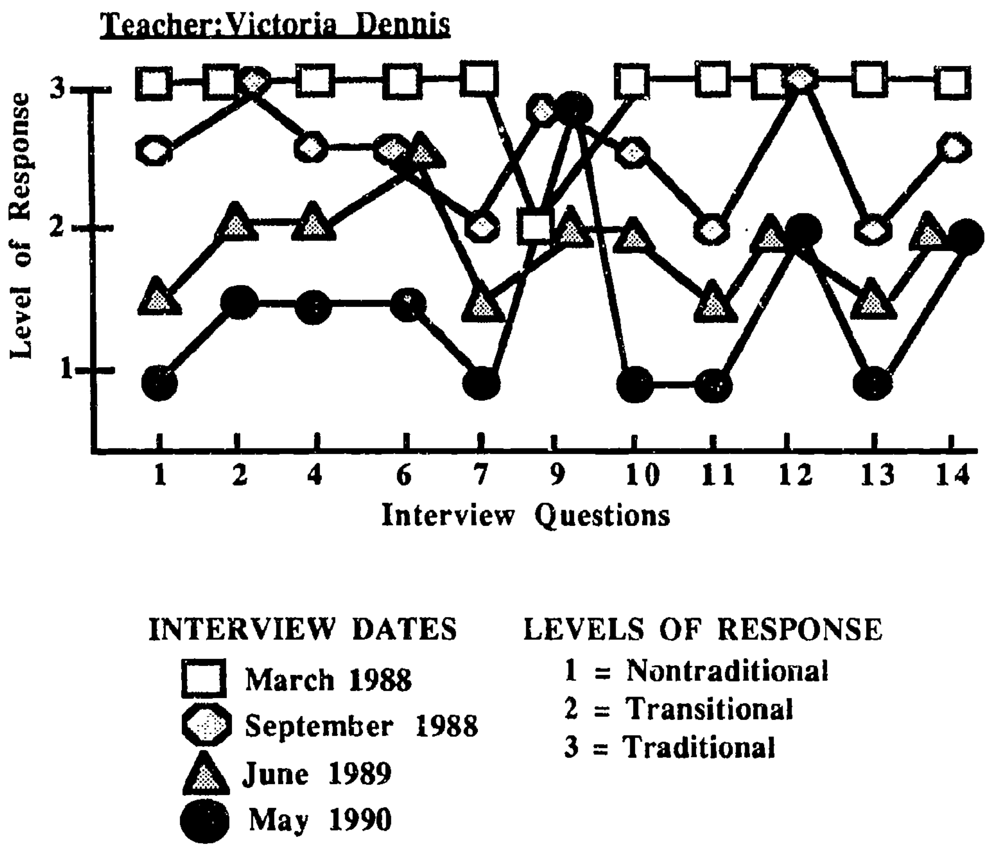

Figure 9. Levels of interview responses of Victoria Dennis.

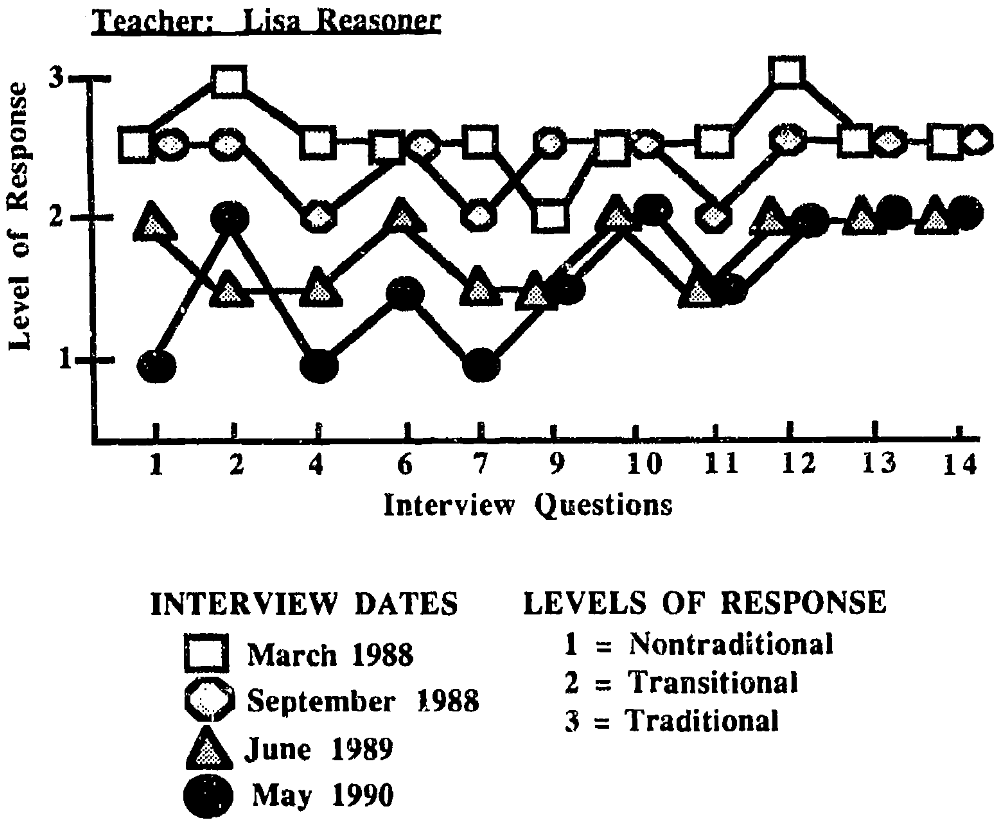

Figure 10. Levels of interview responses of Lisa Reasoner.

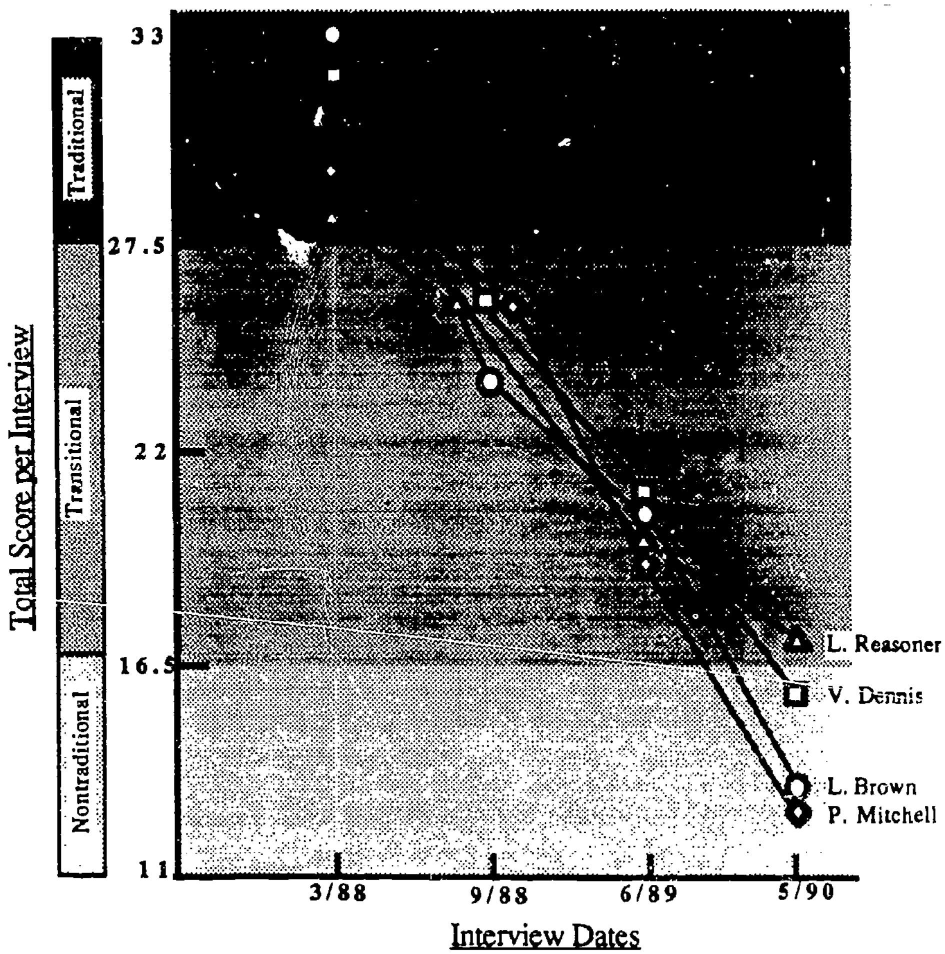

Figure 11. Levels of responses of the science Support Teachers' interviews.

Table 2

Levels of Responses of the Science Support Teacher Interviews

	Support Teacher Interview Results				
Support Teachers	3/88	9/88	6/89	5/90	Change (3/88 to 6/89)
Larry Brown	33	24	20	13.5	Δ 19.5
Victoria Dennis	32	26	20.5	16	Δ 16
Patrick Mitchell	29.5	26	19	13	Δ 16.5
Lisa Reasoner	28	26	19.5	17.5	Δ 10.5

Note: A Level 1 (Nontraditional) score is from 11 to 16.5.
A Level 2 (Transitional) score is from 17 to 27.5.
A Level 3 (Traditional) score is from 28 to 33.

Discussion of the Support Teacher Interview Results

The results of the interviews suggested that (a) the Support Teachers had changed their thoughts about teaching and learning, and (b) the Support Teachers had moved from a more traditional to a more nontraditional orientation by the last interview. However, none of the support teachers had reached the nontraditional orientation until the end of the second year. The results indicate the teachers had changed their thinking regarding the content, communication, and classroom environment. These support the findings of the teaching style inventory. By June 1989, the interview and survey results show the teachers in a transitional stage of their thinking. The interviews of May 1990 show most teachers had moved to a nontraditional view of teaching and learning. Of particular importance is the finding that the change in the teachers' thinking about learning and instruction was gradual and evolved over time. While their thinking had changed, their practice had not yet reached a nontraditional level. None of the teachers felt successful in implementing all the changes they had planned. Research shows that changing teacher practice would take longer (Madsen-Nason, 1988).

Changes in the Support Teachers' Science Curriculum

The Support Teachers described their curriculum before their participation in the program and for the 1990-1991 academic year. The results indicate that the content and curriculum had changed and that the approach to science had become more unified. Figures 12, 13, 14, and 15 describe the curricula of the Support Teachers in 1987-88, at the start of the program, and in 1990-1991.

The science curricula of each Support Teacher had changed. Even though they taught different units of content, there were similarities in the curricular changes they made. They now spent more time studying larger units. Their 1990-91 curriculum was less fragmented than the 1987-88 curriculum. They all reported trying to build a science curriculum that focused on big ideas or concepts and made connections between units of content. Lastly, the teachers selected and implemented new units of science that were outside of the textbook and were concept-oriented, student-centered, and activity-based.

Student Achievement Differences

In late May and early June 1990, as part of the Support Teacher Program, students in the four junior high schools were tested in science to obtain baseline data on student achievement. While we have data from all teachers, analysis of these data was hampered by limitations in our resources and personnel. However, to provide some evidence of the program's effectiveness, a case study of students in two teachers' classes was conducted. The data from a science test developed by the four Support Teachers compared the achievement of honors students in the classes of two experienced science teachers in the same school--one the Support Teacher and the other, a teaching colleague.

Both teachers had more than 15 years of experience. Both were males. One teacher, Brown, the Support Teacher, adopted the instructional approaches fostered by the Support Teacher Program, which included opportunities for students to make sense of and apply scientific knowledge. Observations in Brown's classes showed that he frequently employed group work, student writing, questioning, and discussion strategies that required students to make sense of and apply scientific knowledge.

The other teacher, Davis, had been resistant to the changes proposed by the Support Teacher Program. Observations of his classes showed little use of group work and extended writing by students. Emphasis was on knowledge acquisition, but there were few opportunities for students to make sense of or apply the knowledge that was being learned.

Achievement in the two classes was quite different even though both teachers taught the same content in their classes as agreed upon by all sciecne teachers. The test for seventh graders focused on two topics, photosynthesis and cells, which were key topics in the life-science curriculum at that grade level. The test had two parts--a multiple choice part consisting of 20 questions and an essay part in which students wrote descriptions and explanations. It should be noted that the test was quite demanding. On the multiple choice questions, average scores for students in the two honors classes were as follows:

Brown's students	14 points
Davis's students	10 points

1986-1987

TOPIC	WEEKS
Introduction to Science (and Metrics)	7
Weather	8
Astronomy	7
Fresh Water & Oceans	3
Rocks & Minerals	2
Earthquakes, Volcanoes Plate Tectonics	3
Weathering & Erosion	4
Glaciers	3

1990-1991

TOPIC	WEEKS
Introduction to Science(and Metrics)	6
Weather	12
Astronomy	8
Fresh Water & Oceans	4
Rocks & Minerals	3
Earthquakes, Volcanoes Plate Tectonics	4

Figure 12. Victoria Dennis--science curriculum.

1986-1987

TOPIC	WEEKS
Introduction to Science	
Foundations of Earth Science	~6
Astronomy	~6
Geology	~6
Earth's Atmosphere	~6
Earth's Waters	~6
Earth's History	~6

1990-1991

TOPIC	WEEKS
Introduction to Science(and Metrics)	6
Foundations of Earth Science	~9
Astronomy	~9
Geology	~9
Earth's Atmosphere	~9

Figure 13. Patrick Mitchell--science curriculum.

1986-1987 TOPIC	WEEKS
Introduction to Earth Science	
Matter, Molecules, Energy	8-9
Geology	
Earth's History: Interior and Surface (Rocks, Minerals, Weathering, Erosion, Volcanoes, Plate Tectonics, Etc.)	18
Astronomy	
The Earth in Space (Universe, Galaxy, Solar System)	9-10

1990-1991 TOPIC	WEEKS
Introduction to Earth Science: What Things are Made Of	
Matter, Molecules, Energy, MSU Unit on Matter & Molecules	11
Atmosphere & Weather	10
Hydrology	
Fresh Water & Oceans Meteorology	6
Geology: Earth's Interior	
Earth's History: Interior and Surface (Rocks, Minerals, Weathering, Erosion, Volcanoes, Plate Tectonics, Etc.)	10

Figure 14. Lisa Reasoner--science curriculum.

1986-1987 TOPIC	WEEKS
Scientific Method & Characteristics of Living Things	3
Metric Measurement	1
Basic Chemistry (Elements, Compounds)	2
Classification of Animals	6
Cell Theory	3-4
Plants	3-4
The Human Body: Systems	8

1990-1991 TOPIC	WEEKS
Observation & Inference (Strand Used in Every Unit)	daily
Building Blocks of Living Things (Cellular Respiration, Cellular Reproduction, Cell Theory, Cell Structure, Activities of Living Things)	10-12
Bacteria & Fungi	5
Animal Kingdom (Understanding of the Classifications)	3-4
Plants (Photosynthesis, Plant Structure, Connections to Cell Theory)	3-4
Ecology (Food Webs, Food Chains, Greenhouse Effect)	3-4

Figure 15. Larry Brown--science curriculum.

Students' Results on the Essay Questions

The following are comparisons between Brown's and Davis's students on six essay questions:

1. **The structure and function of cells.** In one question on the essay portion of the test, students were asked to draw a diagram of a cell, label as many parts as they could, and describe the function of these parts. The comparison between the two classes follow:

> Brown's students identified an average of 4.6 parts and described correct functions for 3.1 parts.
>
> Davis's students identified an average of 4.1 parts and described correct functions for 2.3 parts.

2. **Diffusion.** Diffusion was an important process in helping students to understand many phenomena that occur in living beings, including humans. Students were asked to explain how diffusion occurs. Answers to this and the remaining four essay questions were rated as either 0, 1, 2, or 3, and the percentage of students attempting an answer was noted:

Percentage of Brown's students attempting an answer	100%
Average score of students in Brown's class	2.1
Percentage of Davis's students attempting an answer	29%
Average score of students in Davis's class	0.4

3. **Similarities and differences between plant and animal cells.** Another important concept for students to understand pertained to the similarities and differences between plant and animal cells, which students were asked to explain.

Average scores of Brown's students were as follows:	
Similarities	2.0
Differences	2.3
Average scores of Davis's students were as follows:	
Similarities	1.5
Differences	1.4

4. **Different kinds of cells in the human body.** Students were asked to draw and name three different kinds of cells in their bodies. Again, students were scored 0 - 3 on this item.

Percentage of Brown's students attempting an answer	100%
Average score of students in Brown's class	2.6
Percentage of Davis's students attempting an answer	57%
Average score of students in Davis's class	0.6

5. **Observation through a microscope**. Students were also asked to report observations through a microscope to assess their skill in making and reporting observations.

Average score of students in Brown's class	2.3
Average score of students in Davis's class	1.5

6. **Photosynthesis**. In the portion of the test that dealt with photosynthesis the results were similar, favoring students in Brown's class.

		Brown's students	Davis's students
6.	Explanation of a balanced aquarium	2.4	2.0
7.	Comparison of a leaf with a factory	2.3	0.6
8.	Understanding of the source of energy in coal [energy from the sun]	1.4	0.9
9.	Understanding that plants make their own food and that soil and water are raw materials out of which the food is manufactured	2.7	1.0
10.	Understanding that all the food that they eat originates from plants	2.3	1.4

Summary of the Student Test Results

Brown's students outscored Davis's on every item on the test even though both teachers were teaching honors students in the same school. The differences were more dramatic when total scores were compared:

Total score of students in Brown's class	41.8 points
Total score of students in Davis's class	23.0 points

The scores of the students in Brown's class were nearly double those of the students in Davis's class. Students in Brown's class were learning more science as a consequence of the teaching methods that were fostered by the Support Teacher Program. The differences were substantial and the effects over time will make them even more pronounced. This provided very strong evidence of the importance of the Support Teacher Program as a means of improving both teaching and learning in our schools.

Instructional Changes of the Support Teachers

Questioning students and probing their answers led the teachers to a heightened awareness of students' previous knowledge in science. This knowledge was made public, valued, used, and, when necessary, corrected. Answering the question of how he knew when students did not understand, one

Support Teacher said: "Testing did not always tell you what they did or did not know. If you can sit with the kid and have him tell you what he was thinking--then you know." Another Support Teacher said she found herself "listening more to the kids and talking less, having them play it back in their own words" to her.

The Support Teachers were incorporating more group activities where students put together different pieces of information. Previously group work was restricted to lab activities. Now groups of students were used both in the lab, in discussions, and for the interpretation of questions and situations. Most of the science teachers started using concept mapping as a tool to help students link science concepts in creative and meaningful ways. Cooperative groups, concept maps, and new units of content generated the need for teachers to develop higher level tasks.

The teachers were giving more essay questions in their tests and homework assignments in order to gain insight into the students' understanding. They were using "mind-stretchers" to start their classes. A "mind-stretcher" was an open-ended question that linked the day's lesson to the previous lesson and provided the student with an opportunity to write in his/her own words the meaning of a concept or an idea. An event in Patrick Mitchell's class, described in an observation, illustrates the importance the teachers were giving to student expression of concepts and ideas in science:

> Patrick Mitchell was going to start a unit on astronomy some weeks before Christmas. He asked the students in the first class to write what they could remember about the universe in a piece of paper. To do this he gave them 20 minutes. Most students, according to him, wrote three to five lines, some students wrote one or two words. He then collected these papers and kept them. At the end of the unit he gave them the same piece of paper, the same task, and the same time. Most students wrote 1-2 pages, some asked for more paper and others for more time. No one wrote less than half a page. Mitchell took the papers home wrote some comments and gave them back to the students saying: "Take that to your parents and show them how much you have learned. That will be a good Christmas present."

The climate in the four schools had improved from the other teachers being suspicious or skeptical to those same teachers becoming curious and hopeful. Many colleagues of the Support Teachers who questioned and resisted instructional change were now advocates of the program. In every school there was one teacher who resisted, was negative, and became problematic to the Support Teachers. There was also another teacher who was eager to try new things and who looked forward to being helped. The others (two or three teachers) fell somewhere in between.

Comments on the Support Teacher Program

The Support Teacher Program provided the opportunity for teachers to improve the quality of their classroom instruction and to work with their teaching colleagues to improve learning and instruction at a department level within their schools. The Support Teachers reported that their students responded positively to new techniques and instructional ideas they had implemented. Moreover, teachers demonstrated increased confidence and competence which resulted from dialogues with their peers and from engaging collaboratively in significant professional growth activities. Teachers and students alike benefited from the establishment of a new professional role that kept exemplary teachers in the classroom and also extended their influence to other teachers through the establishment of the new role of Support Teachers.

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Appendix

Science Support Teacher Readings

SUPPORT TEACHER READINGS

Support Teacher Role

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